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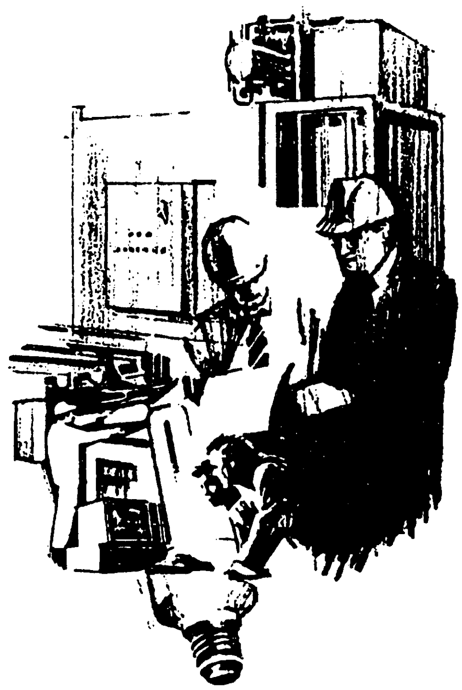
Fort Lewis Electric Energy Baseline and Efficiency Resource Assessment

Executive Summary



October 1991

Prepared for the U.S. Department of Energy
Federal Energy Management Program
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
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FORT LEWIS ELECTRIC ENERGY BASELINE AND EFFICIENCY RESOURCE ASSESSMENT

EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

The mission of the U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP) is to lead the improvement of energy efficiency and fuel flexibility within the federal sector. Through Pacific Northwest Laboratory, FEMP is developing a fuel-neutral approach for identifying, evaluating, and acquiring all cost-effective energy projects at federal installations. FEMP believes that the Bonneville Power Administration (Bonneville), as part of the federal sector and DOE, can actively support the identification, characterization, and procurement of electric energy efficiency resources from federal customers within the Bonneville service territory. For this reason, FEMP approached Bonneville with the proposal to develop a pilot program with a large federal customer in Bonneville's service territory. The purposes of that program would be to identify and acquire all cost-effective electric energy efficiency resources within the customer's infrastructure. FEMP emphasized that, to the extent possible, the pilot program should not require the federal customer to either procure an energy services contractor or provide capital funds. FEMP has identified these two requirements as major obstacles in the path of federal agencies/installations attempting to aggressively pursue energy efficiency programs. Bonneville agreed that significant energy efficiency resources existed within the federal customer base, that a pilot program was warranted, and that it should be designed to overcome these obstacles. FEMP and Bonneville agreed to fund the Pacific Northwest Laboratory (PNL),[a] FEMP's lead laboratory, to identify and recruit a federal customer and to conduct a fuel-neutral efficiency assessment at the federal facility.

It was agreed that the pilot program should be designed to be transferable to other federal customers within the Bonneville service territory. To have maximum impact, the program should also be transferable to federal customers outside of Bonneville's service territory. This condition meant that the program would likely have greater transferability if the federal customer were not served directly by Bonneville but by a utility that purchased power

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from Bonneville. This would give the program maximum credibility when FEMP/PNL transfer the "lessons learned" to other utility service territories and other states.

The conditions just described dictated the criteria that PNL used to identify the most appropriate federal customer to participate in the program. First, we knew from our experiences at over 20 large federal installations that a necessary condition for the program to be successful was that the federal customer be thoroughly committed to working through the process. We also knew that the federal customer needed to be served by a utility committed to innovative approaches in demand-side management programs--ideally, a utility that had demonstrated commitment to the fundamental principles of least-cost planning.

Fortunately, all conditions were quickly met. FEMP has a cooperative program with the Army Forces Command (FORSCOM) for providing technical assistance to FORSCOM installations. FEMP and FORSCOM have agreed to cost-share activities in developing innovative approaches to energy efficiency at the latter's installations. One of those installations is Fort Lewis (near Tacoma, Washington), with whose key staff PNL had already developed a working relationship. In addition, Fort Lewis is served by Tacoma Public Utilities (TPU), which has demonstrated a commitment to energy efficiency programs over the years and enthusiastically embraced the concept. All these parties became involved in the pilot program.

The overall goals of the pilot program are

- to demonstrate a model approach for identifying and characterizing all cost-effective energy efficiency at Fort Lewis such that the approach can be transferred to other federal installations
- to acquire all cost-effective energy efficiency identified and characterized at Fort Lewis
- to acquire all cost-effective electric energy efficiency at Fort Lewis through a TPU/Bonneville agreement that would not require the Fort to either procure energy service contractors or provide any up-front capital.

The latter goal can be accomplished through the Targeted Resources Acquisition Program offered by Bonneville. This program enables utilities that purchase power from Bonneville to identify and buy electric energy efficiency resources from the utilities' customers, then sell those resources back to Bonneville for use elsewhere in its service area. However, to take full advantage of this program, utilities such as TPU must prepare a proposal to Bonneville that tells the agency where and what the potential resources are, and how the utility plans to evaluate those estimated resources to determine their actual extent. The federal installation whose potential resources are being estimated also needs this information so it can decide whether or not to commit its share of the cost of the recommended retrofits.

In this report, we describe PNL's assessment of the electric energy efficiency resource potential at Fort Lewis. Through this assessment, we developed an estimate of the electricity use baseline and efficiency improvement potential for major sectors and end uses at the Fort. Developing the baseline was essential to segment the end uses that are targets for broad-based efficiency improvement programs and to provide TPU with the basis for its proposal to Bonneville. An estimate of the efficiency resource is presented to reflect the available quantity of resource for three electricity price ranges. The baseline and efficiency resource estimates did not identify all possible areas of opportunity, but instead identified the majority of the resource; areas of additional opportunity are noted, to encourage further effort.

BASELINE ELECTRICITY USE

Fort Lewis houses approximately 25,000 full-time residents. The Fort has a daytime population of approximately 35,000 persons. The annual fuel consumption is about 2.5 trillion Btu, of which 26% is in the form of electricity (annual average of 195,000 MWh). The annual cost of energy supplied to the Fort is over $12 million, of which about $4.5 million is for electricity.

In developing the baseline electricity use, we segmented the Fort into sectors, subsectors, and end uses to reflect major areas of consumption and efficiency potential. The four sectors identified were buildings, pumps/motors, distribution, and exterior lights. The sectors were further segmented into subsectors and, in the case of buildings, end uses (interior lighting, domestic hot water [DHW], refrigeration, and other).

An estimated 4457 buildings with floorspace of 23.9 million ft^2 are on the installation. We segmented the buildings sector into 16 subsectors (building types) based upon function and uniqueness of operation. Nine of the building types account for over 90% of the total floorspace. Principal contributions are family housing at nearly 25%, barracks at nearly 20%, office/administration and warehouse each at over 12%, other at nearly 9%, the New Madigan Hospital at over 8%, and motor pools with 8% of the total floorspace.

End uses identified in the buildings sector include five lighting type categories, domestic hot water supplied by residential-type water heaters, refrigeration supplied by residential-type refrigerators, and all other uses. The other category contains heating, ventilating, and air-conditioning (HVAC) energy end uses that are specific to each building type. HVAC energy use was not separated because almost all heating energy is supplied by fossil fuel and few buildings are cooled; electricity use for HVAC is primarily for fans and pumps.

The pumps/motors sector reflects electricity use for large pumps and motors (10 to 250 horsepower) used for the water supply and sewage treatment subsectors. The distribution sector accounts for the losses incurred for electricity distribution through the transformer and feeder subsectors. We segmented the exterior lights sector into three subsectors: residential, nonresidential (building exterior and parking lot lighting), and street lighting.

The limited availability of metered data created a challenge in developing the baseline electricity use. The Fort is served by three substations, designated as Madigan, South, and Central. Each is metered separately by TPU for both demand and power use. Aside from the commercial (nonappropriated) buildings on the Fort, these are the only sites where electricity use for the installation is metered. Seventeen feeder lines from these three substations provide all electrical power to the Fort.

We metered each of the substations and feeders separately and collected time-series data for 4 consecutive months. The primary purpose of the metering was to measure the electric demand profile of the Fort and determine the relative contributions to that demand of each of the three substations and

17 feeders. The secondary purpose was to provide the only metered data for an accurate assessment of the electrical energy use intensities of the building stock.

We used the metered data to ascertain and pinpoint the potential for energy efficiency opportunities in the various sectors of the site served by the 17 feeders, for both demand and baseload savings. The data were also used to more accurately determine the estimated energy use and energy use intensities of each of the major building and facility types at the Fort. Without these feeder-level metered data, we would have had to perform the analysis using TPU's billing data from the three substations. Thus, much more uncertainty would have been associated with this foundational analysis.

The metering results showed that the Fort has an annual baseload demand of 15,000 to 17,000 kW, and that the peak demand of 27,000 to 30,000 kW usually occurs before noon, depending upon the season. The Central substation accounted for nearly 50% of the total Fort demand. From the data, we also determined that most of the 16[a] feeder loads were not temperature-dependent; therefore, opportunities for electrical energy savings (kilowatt-hours) exceed the opportunities for demand savings (kilowatts).

The baseline electricity use displayed in Table S.1 was developed for the buildings sector end uses and estimated subsector consumption or losses for the other three sectors. The estimates were developed using limited primary energy use data for the Fort, other studies conducted to identify efficiency improvements at the Fort, input from installation staff, and other published studies. The estimated annual energy use of 197,000 MWh was not adjusted to match the average actual of 195,000 MWh from billing data.

The buildings sector accounts for over 85% of the electricity use. Four of the building types account for over 46% of the total; these were single-family at 12.9%, multifamily at 10.7%, concrete barracks at 11.4%, and office/administration at 11.5%. Pumps/motors consume an estimated 2.4% of the total, distribution losses 7.6%, and exterior lighting nearly 4%.

(a) One of the feeders was a switching alternate and no load was measured during the monitoring period.

TABLE S.1. Estimated Baseline Electricity Use Per Year by Sector, Subsector, and End Use

Sector	Estimated Baseline Electricity Use (MWh)				
	Lighting	DHW	Ref	Other	Total
Building					
Single-Family	4,210	9,287	2,477	9,339	25,313
Multifamily	3,713	7,650	2,040	7,707	21,110
Concrete Barracks	10,431			12,064	22,495
Wood Barracks	1,088			982	2,071
Office/Administration	10,368	1,817		10,478	22,663
Warehouse	6,025	26		4,990	11,041
Motor Pool	5,122	1,140		3,682	9,944
Hangar	1,084	92		912	2,088
Dining Halls	1,252			5,955	7,207
Clubs	1,154			2,410	3,565
Old Madigan Hospital	4,502			8,807	13,309
New Madigan Hospital	5,959			2,023	7,982
Commissary	735			4,515	5,250
Computer Center	118			376	494
Simulators	230	3		4,564	4,797
Other	4,873	637		4,249	9,759
Subtotal	60,867	20,653	4,517	83,053	169,088
Pumps/Motors					
Water Supply				3,600	3,600
Sewage Treatment				1,160	1,160
Subtotal				4,760	4,760
Distribution					
Transformer Loss				13,000	13,000
Line Loss				2,000	2,000
Subtotal				15,000	15,000
Exterior Lights					
Residential	1,290				1,290
Other Building	2,453				2,453
Street	4,000				4,000
Subtotal	7,744				7,744
Total	68,611	20,653	4,517	102,813	196,591
% of Total	34.9	10.5	2.3	52.3	100.00

Of the total consumption, nearly 35% is accounted for by lighting, over 10% by domestic hot water, over 2% by refrigeration, and the balance of 52% by other uses. Within the lighting end use, approximately 22% of total electricity is fluorescent lighting energy, of which most is consumed in fixtures with 4-ft F-40 type tubes. Incandescent and high-intensity-discharge (HID) lighting account for 8.7% and 4.4%, respectively, of the remainder of total electricity consumption.

ELECTRIC EFFICIENCY RESOURCE SUPPLY

The supply of the electric efficiency resource was estimated for all subsectors and end uses except the other category in the building subsectors. The quantity of energy resource available was estimated for three electricity price ranges: $0 through $0.023/kilowatt-hour (kWh), $0.024 through $0.045/kWh, and $0.046 through $0.075/kWh. The endpoint of the first price range chosen is the approximate price that Fort Lewis currently pays for electricity (including demand charges), the endpoint of the second price range is the approximate avoided cost for new electricity generation in the Pacific Northwest, and the endpoint of the last cost range is chosen as an arbitrary point beyond which there is clearly no cost-effective technology options.

The potential menu of efficiency measures considered by sector and end use was as follows:

Buildings

Interior Lighting

- Replace incandescent bulbs with compact fluorescent in 15% of the indoor residential fixtures, 75% of the indoor fixtures in other buildings, and 100% of the exterior fixtures.
- Replace standard magnetic ballasts with energy-efficient magnetic ballasts in two-tube fluorescent fixtures using 34-, 40-, and 75-W tubes.
- Replace standard magnetic ballasts with electronic ballasts in two-tube fluorescent fixtures using 34-, 40-, and 75-W tubes.
- Replace standard magnetic ballasts with tunable electronic ballasts in two-tube fluorescent fixtures using 34-, 40-, and 75-W tubes.

- Add parabolic reflectors to two-tube fluorescent fixtures using 34-, 40-, and 75-W tubes.

- Replace two-tube fluorescent fixtures using 34-, 40-, and 75-W tubes with new fixtures with reflectors and electronic ballasts.

- Replace two-tube fluorescent fixtures using 75-W tubes with 150-W high-pressure sodium lamps.

- Replace two-tube fluorescent fixtures using 75-W tubes with single-tube 75-W very-high-output (VHO) fixtures.

- Replace two-tube fluorescent fixtures using 34- and 40-W tubes with F-30 T-8 fixtures.

Lighting replacements were made on a constant level of service basis. That is, if a replacement put out twice the level of light (measured in lumens), a one-for-two replacement was used.

Domestic Hot Water

- Increase the insulation level of the tanks by wrapping all of the water heaters with insulation.

- Wrap only new water heaters (less than 2 years old) with insulation.

- Replace 100% of existing water heaters with high-efficiency water heaters with nonmetallic or lined tanks. Information from the Fort Lewis staff indicates that life expectancy for water heaters is less than 5 years due to tank corrosion caused by carbonic acid. In addition, TPU staff encouraged consideration of a water heater replacement program with high-efficiency models, as that utility has experienced greater success with a replacement program than with wrap programs.

- Replace water heaters upon failure with high-efficiency water heaters with nonmetallic or lined tanks.

Refrigeration

- Replace 100% of existing residential-type refrigerators

Replacing refrigerators with high-efficiency models as they wear out rather than implementing a straight replacement program as above was not considered because it is understood that all models now available are of the "efficient" variety. Consequently, tnere is little differential between replacement options.

Pumps/Motors

Water Supply

- Totally replace well pump motors with high-efficiency motors.
- Replace well pump motors with high-efficiency motors upon failure.

Sewage Treatment

- Totally replace sewage treatment pump motors with high-efficiency motors.
- Replace sewage treatment pump motors with high-efficiency motors upon failure.

For both the water supply and sewage treatment subsectors, existing motors were assessed individually for replacement because the number of operating hours varied significantly, which has a large effect on the levelized energy cost. The cost and efficiency improvement also varies with motor size.

Distribution

Transformer Loss

- Replace existing transformers with high-efficiency units. Existing transformers were assessed by size category for replacement.

Line Loss

- Regulate the voltage of the distribution system so that the most distant point on individual feeders meets minimum voltage requirements under all load conditions. Although insufficient information to quantify the resource is available for this measure, it is estimated to provide a reduction of 1% to 3.5% in total baseload at a very low cost (up to $0.01/kWh).

Exterior Lighting

Residential

- Replace 100% of incandescent bulbs with compact fluorescent bulbs.

The levelized energy cost (LEC), net present value (NPV), and annual efficiency resource availability of each measure considered are displayed in

Table S.2. The regional power planning perspective using LEC shows the cost of the measures ranging from $0.0056 to over $0.158/kWh. The federal sector perspective using NPV is shown for the Fort paying 15% of the capital cost and 100% of the operations and maintenance (O&M) cost.

The data developed and displayed in Table S.2 will allow the utility and Fort to choose the electric energy efficiency measures to install in the site-wide retrofit. The choices will hinge on the final cost-sharing agreement as well as the agreement on the LEC ceiling value and NPV criteria. A federal agency is required to select energy efficiency options based on the NPV. The option with the highest NPV is selected. The decision criteria for a utility to choose among energy efficiency measures is based on the LEC.

Using the LEC values, efficiency measures up to the cost of the marginal supply resource for Bonneville ($0.045/kWh) may be considered cost-effective. Using the NPV approach, measures with the highest NPV may be considered cost-effective by the Fort. The choice is generally options that are below the utility's avoided cost (long-run marginal cost) of supplying electricity.

All options that are not part of mutually exclusive sets that have an LEC less than the avoided cost should be selected. Options that are part of mutually exclusive sets should be chosen if they have the LEC closest to the avoided cost of energy, but not exceeding it.

For example, based on NPV, the best choice for retrofitting fluorescent lighting fixtures having 40-W tubes was determined to be a total new fixture with electronic ballast and reflector (the choice shown in Table S.2). This choice also shows a LEC of $0.0166/kWh which will also be acceptable to the utility. Another viable choice for fixture replacement may be retrofitting with a higher efficiency type T-8 fixture. The NPV (shown in Table S.2) is near that of the high efficiency fixture and the LEC is $0.0245/kWh, below the Bonneville avoided cost. However, the marginal LEC for this retrofit is $3.7801/kWh which is well above the long-term avoided cost. Based on these data, this technology may not be selected.

Other choices analyzed included ballast replacement (only) or adding reflectors for replacement (not shown in Table S.2). These had a lower NPV, a

TABLE S.2. Levelized Energy Cost, Net Present Value, and Resource Availability by Efficiency Measure

Efficiency Measure	Levelized Energy Cost ($/kWh)	Marginal Levelized Energy Cost ($/kWh)	Net Present Value (1991 $ thousands)	Marginal Annual Resource Availability (kWh)	Marginal Initial Capital Cost (1991 $ thousands)
DHW: ROF(a)	0.0056	0.0056	1,935	2,427,754	1,439
WS: ROF - Well #18	0.0066	0.0066	4	13,810	1
DHW: Complete replacement(a)	0.0057	0.0081	2,126	2,595,185	1,572
Fl-75-W: New fix. w/refl., ballast	0.0098	0.0098	410	1,318,273	220
Fl-40-W: New fix. w/refl., ballast(b)	0.0166	0.0166	7,453	25,915,995	6,662
Fl-34-W. New fix. w/refl., ballast(c)	0.0167	0.0167	278	957,498	250
ST: ROF - Effluent pumps	0.0181	0.0181	9	30,747	8
Inc.: Replace w/compact fl	0.0203	0.0203	981	6,199,405	754
TRANS: 50 kVA Transformers	0.0210	0.0210	518	1,500,308	619
TRANS: 37.5 kVA Transformers	0.0228	0.0228	238	699,314	313
WS: ROF - Well #19	0.0251	0.0251	1	5,522	2
WS: ROF - Well #15	0.0263	0.0263	2	6,955	3
TRANS: 25 kVA Transformers	0.0275	0.0275	198	606,455	327
TRANS: 75 kVA Transformers	0.0335	0.0335	267	865,947	569
WS: ROF - Well #10	0.0357	0.0357	(d)	32	(d)
TRANS: 100 kVA Transformers	0.0373	0.0373	36	120,387	88
WS: ROF - Sequal spring	0.0562	0.0562	5	24,573	21
WS: ROF - Well #13	0.0567	0.0567	(d)	2,869	2
TRANS: 200 kVA Transformers	0.0605	0.0605	86	374,132	443
WS: ROF - Well #14	0.0613	0.0613	(d)	3,528	3
WS: ROF - Well #12	0.0613	0.0613	1	7,498	7
TRANS: 15 kVA Transformers	0.0771	0.0771	37	205,211	310
TRANS: 300 kVA Transformers	0.0800	0.0800	35	206,202	324
Fl-40-W: Install F30 T-8 fixtures(b)	0.0245	0.1061	7,059	28,399,233	9,690
Refrigerators: Replace	0.1113	0.1113	80	1,387,167	1,843
WS: ROF - Well #9	0.1165	0.1165	(d)	494	(d)
TRANS: 500 kVA Transformers	0.1180	0.1180	13	208,314	482
TRANS: 750 kVA Transformers	0.1333	0.1333	3	176,512	461
TRANS: 1000 kVA Transformers	0.1410	0.1410	(d)	53,305	147
TRANS: 1500 kVA Transformers	0.1419	0.1419	(c)	92,446	257
TRANS: 5 kVA Transformers	0.1564	0.1564	(d)	6,398	20
TRANS: 2500 kVA Transformers	0.1582	0.1582	(d)	15,074	47
WS: ROF - Well #17	0.2615	0.2615	(d)	878	3
Fl-34-W: Install F30 T-8 fixtures(c)	0.0245	3.7801	246	959,483	340

(a) These measures are mutually exclusive and only one will be selected.
(b) These measures are mutually exclusive and only one will be selected.
(c) These measures are mutually exclusive and only one will be selected.
(d) NPV is negative and therefore not considered as a viable measure.

negative marginal energy savings compared to complete fixture replacement. These technologies also had higher LECs compared to the complete fixture replacement.

Examination of the results of the analysis with the estimated cost-sharing split in Table S.2 shows that the choice of criteria (LEC or NPV) will not significantly affect the ultimate choice of energy efficiency measures to be installed at the Fort. The most desirable measures, in terms of both overall energy savings and in terms of NPV, could be selected and implemented using either criteria.

The LEC and resource availability are displayed in Figure S.1 in the form of a supply curve. This shows availability of about 43,000 average annual MWh of electric efficiency at a cost of less than $0.037/kWh. Above $0.037/kWh, less than an additional 1,500 MWh are available.

Figure S.2 shows the resource availability by end use for LEC cost ranges of $0 to $0.023/kWh, $0.024 to $0.045/kWh, and $0.046 to $0.075/kWh. In the lowest cost range, over 37,000 average annual MWh (equivalent to over 4 average annual MW of capacity) are provided by efficiency improvements to water heaters, water supply pumps, interior lighting, exterior lighting, water treatment pumps, and voltage regulation at an estimated initial capital cost of about $9 million. Other transformer and water supply pump replacements, in addition to a different set of lighting and water heating improvements, contribute another 5,907 MWh to the resource potential for the mid-range cost. The upper cost range contains another 412 MWh provided by additional water supply pump and transformer replacements. Lighting measures account for over 90% of the efficiency resource available in the lowest cost range and nearly 85% of the resource of the total available up to a cost of $0.075/kWh.

ADDITIONAL RESOURCE OPPORTUNITIES

A number of additional resource opportunities were identified in the assessment. Their potential contribution was not quantified because they are

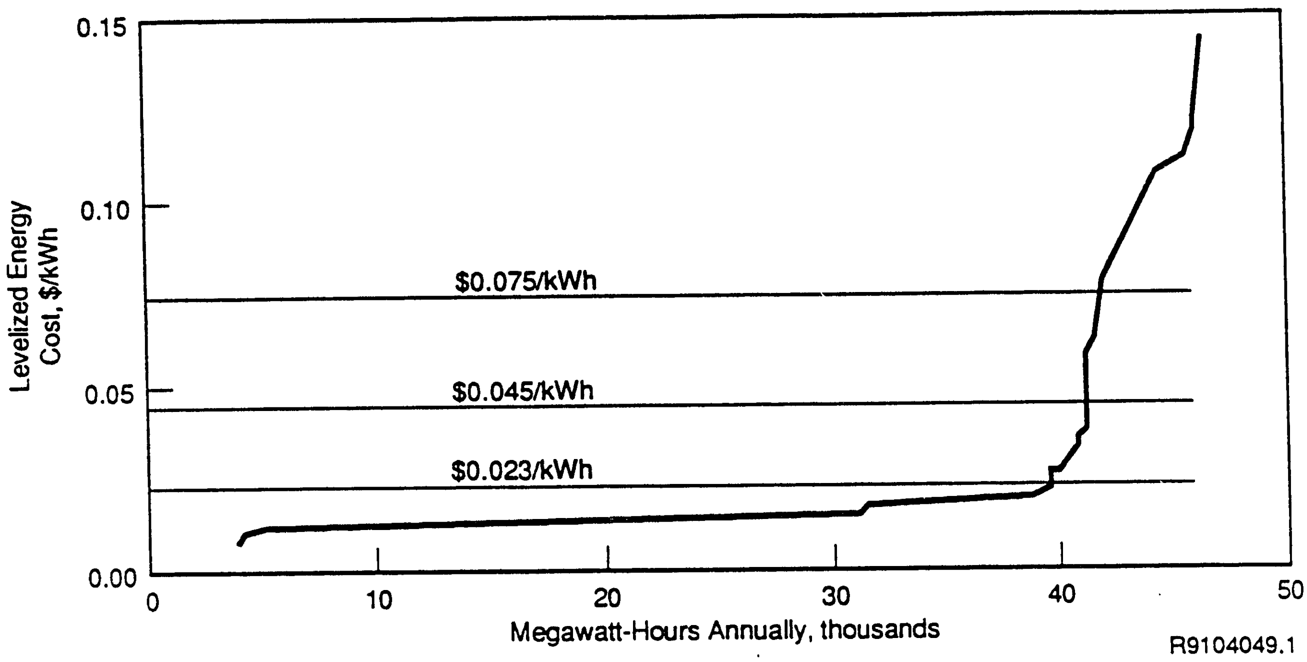

FIGURE S.1. Electric Efficiency Supply Curve

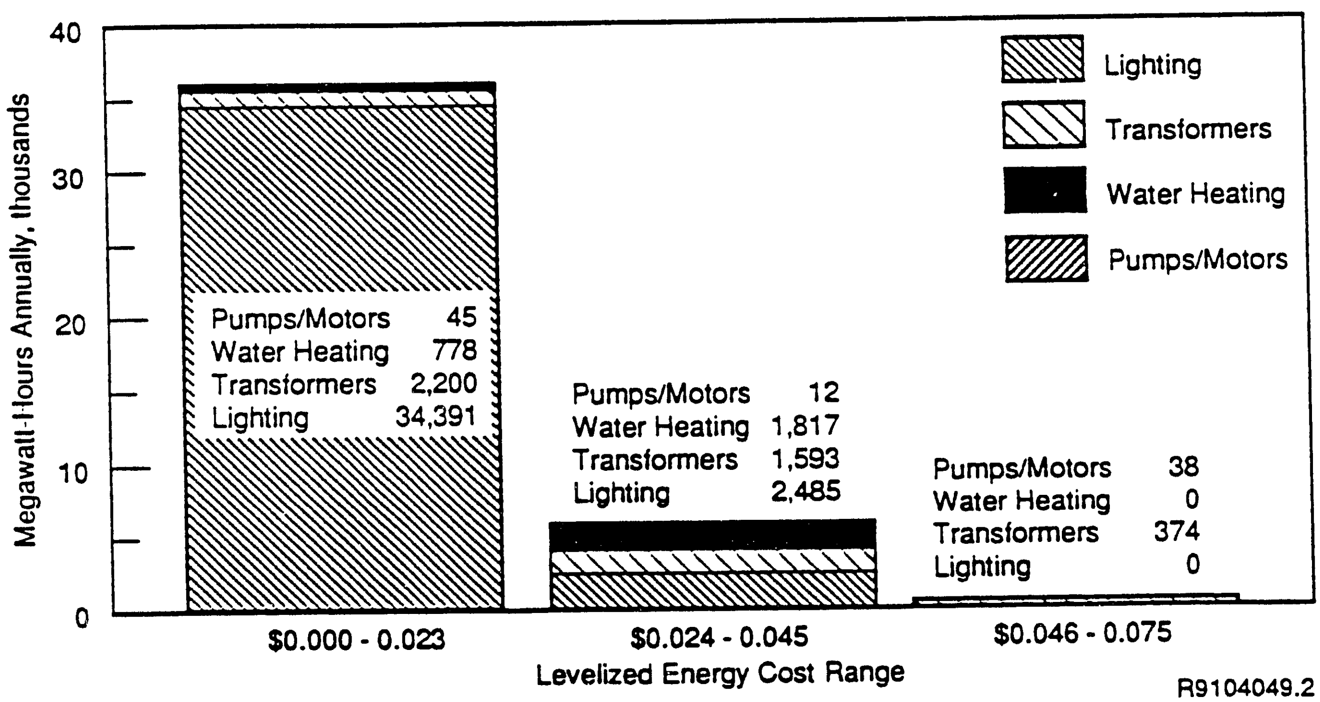

FIGURE S.2. Electric Efficiency Resource by End Use and Cost Category addressable only through more focused data collection efforts, which are beyond the scope of this initial effort. A listing of these resource opportunities by sector follows.

Buildings

- incandescent lighting - Replace those fixtures currently unable to accommodate compact fluorescent lamps to increase the penetration levels in addition to replacing bulbs in fixtures that will accept them.

- lighting controls - Implement controls to adjust for daylighting and/or occupancy. Daylighting controls are reportedly in operation in Building 3670.

- HVAC - Improve heating and/or cooling efficiencies in buildings having electric heating and/or cooling equipment through a combination of higher-efficiency equipment, improving the building envelope thermal integrity, and/or improving operation and maintenance practices.

- heat recovery - Recover heat from exhaust airstreams in building types such as dining halls and clubs.

- low-flow shower heads - This measure is reported to be in place in most, if not all, applications.

Pumps/Motors

- replacement of motors less than 10 horsepower - This option would likely have high potential for motors that operate nearly continuously. However, an inventory of the stock and operating schedules of small motors was not available, nor was an estimate developed.

- modification of related systems - One example would be to increase pipe size to reduce horsepower required to maintain pressure.

- implementation of operation and control practices - This provides for automated operation of the water supply system.

Distribution

- replacement of existing transformers as they fail with high-efficiency units, which may improve the cost-effectiveness of this measure

- the value of other distribution improvements, such as reconductoring feeders and adding capacitors, will reduce line losses and improve power factors.

Exterior Lighting

- installation of new, and replacement of faulty, photocells to reduce or eliminate exterior lighting during daylight hours
- replacement of existing low-efficiency HID lighting with high-efficiency units
- replacement of incandescent lamps that are greater than 200 W with HID or other suitable high-efficiency alternative.

RECOMMENDATION

Our analysis indicates that significant cost-effective energy efficiency potential exists at Fort Lewis. At $0.023/kWh, about 37,000 annual MWh of energy efficiency are available at an estimated capital cost of $9 million. The Fort's electrical utility, TPU, has available several demand-side program options through its supplier, Bonneville. The most likely option appears to be the Bonneville Targeted Acquisition Program under which TPU purchases the efficiency from Fort Lewis and sells it to Bonneville at Bonneville's avoided cost of electricity, which is about $0.045/kWh. The terms of the arrangement being discussed would have Fort Lewis contribute 15% of the capital investment, with the balance funded by TPU and Bonneville. Provided that there are no unresolvable contractual and technical issues, the potential exists for Fort Lewis to enter into an agreement with TPU for the approximately 37,000 annual MWh (4 annual average MW) of cost-effective energy efficiency resources identified.

The PNL assessment is a first cut at estimating the electrical energy efficiency potential at Fort Lewis. As such, the results should be useful to the Fort in determining if an aggressive energy efficiency program is warranted and, if so, which options should be implemented. Our results should not be used to draw conclusions regarding the cost-effectiveness of marginal technologies or specific end-use products. These refinements require more detailed analyses.

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